SUSTAINABLE MANAGEMENT OF THE MEXICAN CARIBBEAN

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INTRODUCTION

The Mexican Caribbean is one of the most biodiverse regions on the planet (Myers et al., 2000), and coastal and marine ecosystems are the main elements of the attraction of the region for tourists. It is estimated that over 20 million tourists visited the Mexican Caribbean in 2022 (Figure 1), generating more than 20 billion dollars (SEDETUR, 2023). The current, dramatic, overexploitation of the region brings complex challenges related to socio-economic development and the conservation of the ecosystems (Figure 2). The possible loss of these ecosystems puts the Mexican Caribbean at risk as a tourist destination.

Despite the economic importance of tourism in the Mexican Caribbean, the degradation of key coastal-marine ecosystems is a constant threat to this and other activities.

WHAT ARE THE MAIN CHALLENGES?

1) The rational use, and conservation, of natural resources has been continuously ignored by coastal managers. To restore their health and resilience, the coral reefs, seagrass beds, coastal lagoons, coastal dunes, mangroves and wetlands require innovative technologies.
2) Such intensive touristic activity demands a considerable amount of electric power, and this has been increasing rapidly. On the other hand, 98% of the energy production in the area is through turbogas, with a very small amount from internal combustion (diesel) and wind power (Chávez et al., 2023). Finding renewable energy sources, such as marine energy, is vital.
3) Massive influxes of the brown algae sargassum in the Caribbean (Figure 3) has brought many socioecological negative effects. Developing a circular economy would change the management of the algae: using it as a primary resource in various applications (Saldarriaga-Hernandez et al., 2020), e.g. producing sargassum-based membranes and filters to treat polluted water and construction materials.

Unfortunately, each of these challenges has always been treated separately:

a) The restoration of corals and/or seagrass meadows by ecologists never properly considers hydrodynamic aspects in determining residence times to ensure proper water quality, or the the conditions under which larvae and seeds are transported by ocean currents.
b) On the other hand, engineers characterise marine-coastal ecosystems in a simplistic way, modelling them through friction coefficients and, perhaps, considering some mechanical parameters, without assessing the conditions under which these ecosystems and associated habitats become established, mature and regenerate, often modelling conditions under which these ecosystems cannot develop.

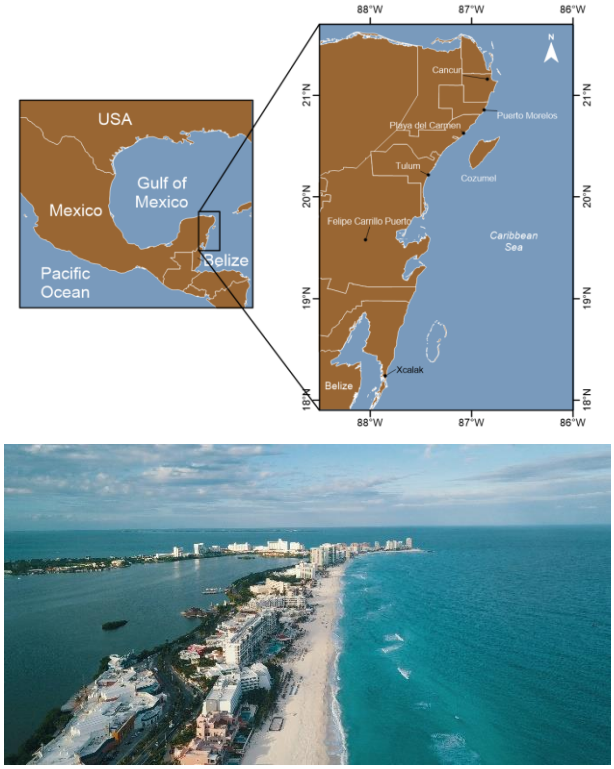

Figure 1 - Location of the Mexican Caribbean, and, below, Cancun - one of the most important tourist destinations in Mexico. Photo by Gerson Repreza in Unsplash.

Figure 2 - Challenges associated with the sustainable

management of the Mexican Caribbean

Figure 3. The massive quantities of sargassum on beaches in the Mexican Caribbean have high temporal and spatial interannual variations.

c) Tourism development plans have made only considering economic aspects and the preferences of potential tourists. However, the vast majority of the goods consumed in the resorts come from faraway, even abroad, thus producing a large ecological footprint.
   In recent years, many initiatives undertaken by the Mexican government to harvest solar and wind energy have failed, either because of their vulnerability to hurricanes or because of social rejection due to a generalised perception that renewables could bring negative impacts on the landscape.
d) The actions employed to tackle the problem of sargassum aim only to maintain adequate conditions for beach tourism. For this, hundreds of millions of dollars a year are spent on the detection, and containment of the sargassum at sea, and its collection from the beaches.
   However, we need to improve our knowledge of the transport mechanisms of sargassum in shallow water, the interaction with barriers or its dynamics on the beaches,in order to suggest integrated solutions. Such solutions should focus on avoiding lixiviates that increase the turbidity and acidity of the water, as the sargassum decomposes. These changes in water quality have induced the death of key ecosystems that provide protection and sediment to the beaches.

To address these challenges, coastal engineering must be strengthened by transdisciplinary applied research, that includes developing integral solutions and diversifying economic activities.

CONCLUSIONS

Understanding waves, currents and wind patterns is fundamental in developing successful ecosystem restoration plans, selecting sites for marine energy harvesting and understanding sargassum transport mechanisms. Providing this knowledge at local scale, as input for other disciplines, is a relevant challenge we address in this study.

For this purpose, within the framework of a project of the National University of Mexico, specialists from various fields of knowledge (coastal engineers, oceanographers, materials engineers, biologists and ecologists) are working in a transdisciplinary way.

Some preliminary results involve modifications in hydrodynamics for the restoration of seagrass meadows; hydrodynamic-based techniques that optimise the harvesting of sargassum and its valorisation; and; determination of sites that meet the appropriate conditions for harvesting the energy of marine currents in the Cozumel channel (sufficient hydrodynamic resources for energy generation, no affectation of key ecosystems, socially acceptable and economically profitable).

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